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(54) **Laminated stator for D.C. permanent magnet electric motor**

(57) A fractional horsepower PMDC motor has a laminated stator housing 3 made up of laminations 4. The laminations 4 have a recessed inner edge 21 for receiving high energy magnets 22 and a castellated outer periphery to improve the thermal emissivity of the casing. The use of a laminated housing 3 allows the adoption of a thicker wall than for conventional deep drawn steel casing, giving an improved flux return path for the magnets.

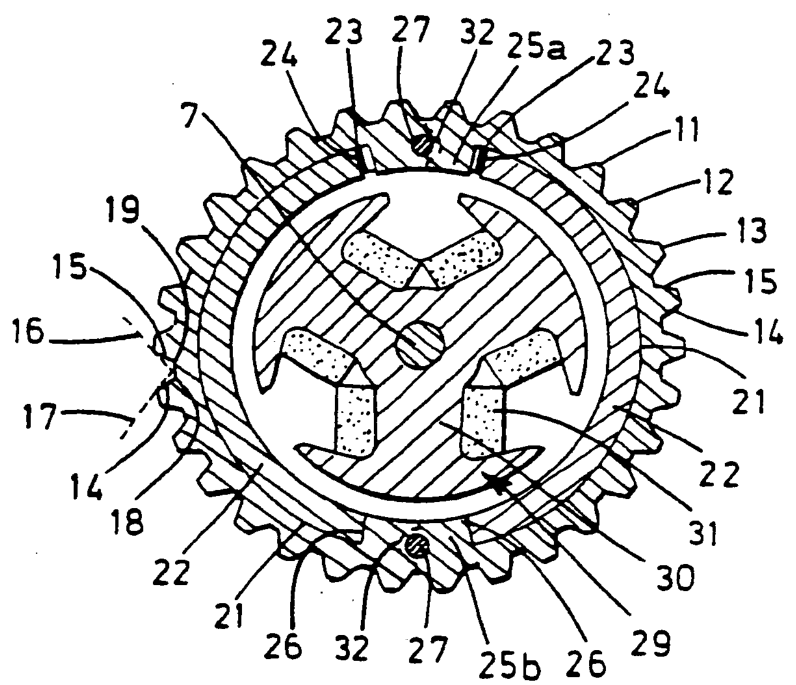


FIG.2.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy

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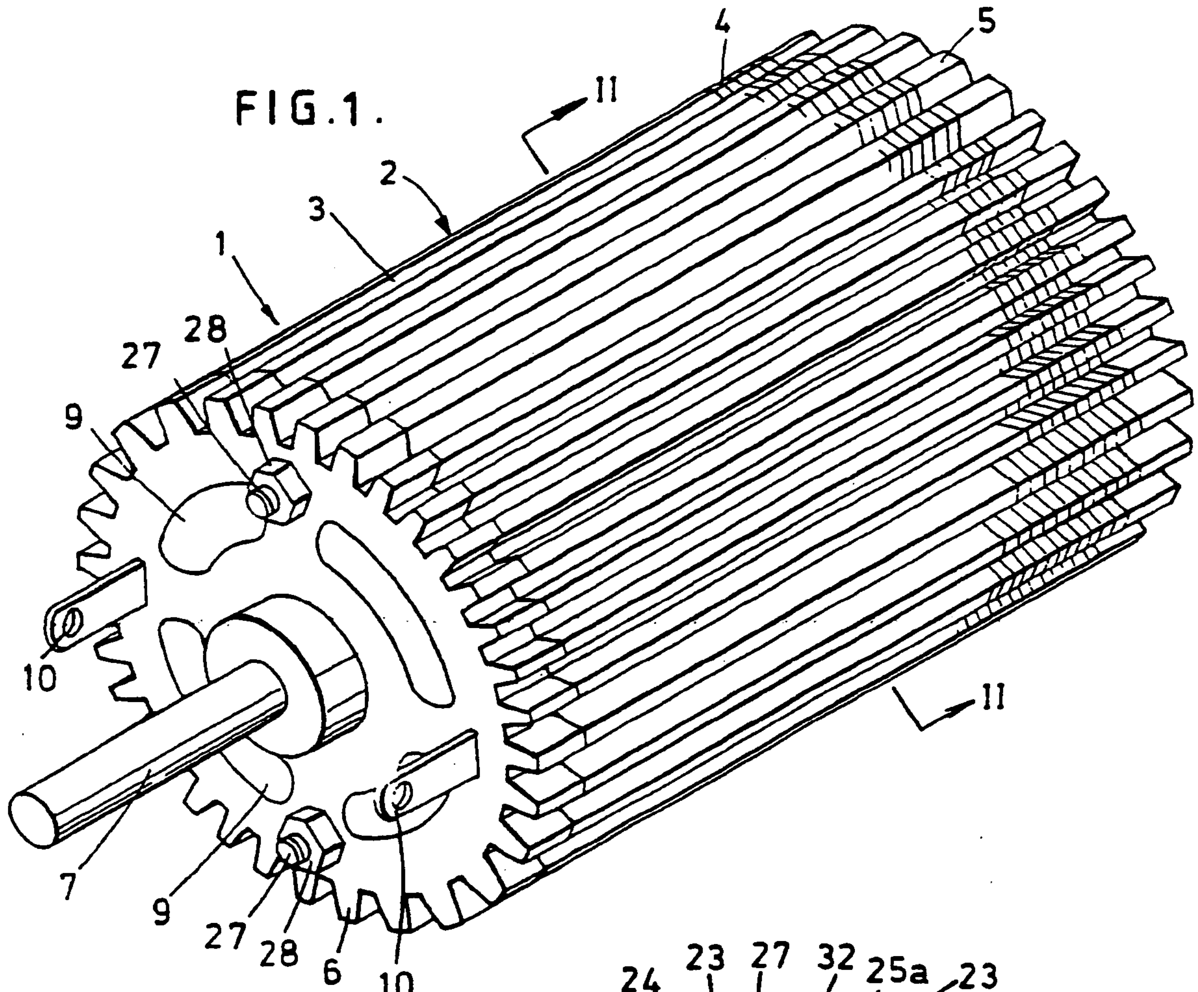
FIG.1.



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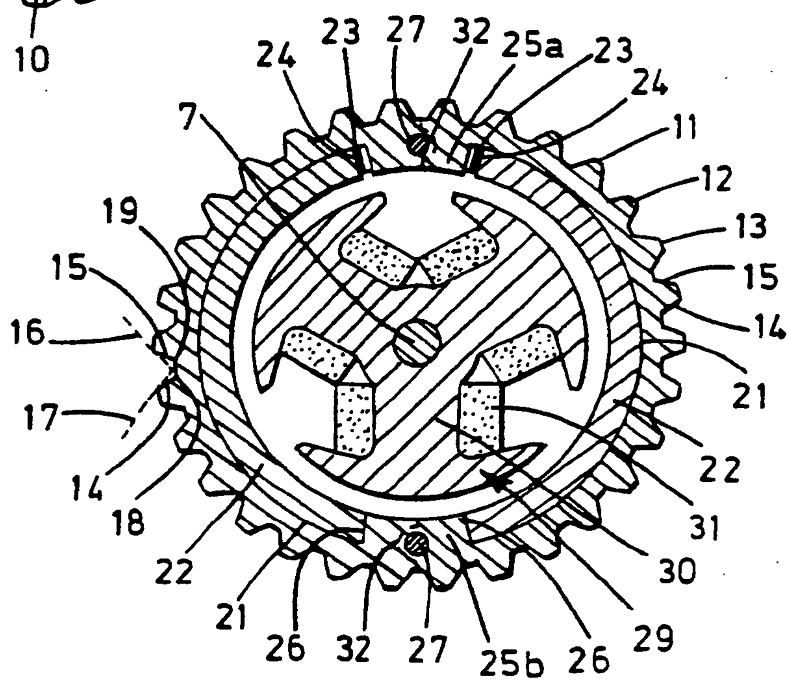

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FIG.2.

# LAMINATED STATOR FOR AN ELECTRIC MOTOR

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The present invention relates to an electric motor, and in particular to a fractional horsepower permanent magnet direct current (PMDC) motor, particularly motors of less than 0.5 horsepower.

Manufacturers of PMDC micromotors are continually called upon to improve the power to volume ratio of the motor to meet the needs of an increasing range of sophisticated, battery operated tools and toys.

The introduction of rare earth magnets has made it possible to increase the power to volume ratio, but the cost of these magnets is too high for general use in low cost PMDC micromotors, and the high magnetic remanance means that conventional armature designs, cannot be used.

A further recent development has been the process of making neodymium - iron-boron (N.I.B.) magnets by a quenching procedure. This has considerably reduced the cost of the magnets. Furthermore by mixing N.I.B. powder with a binder such as epoxy powder a magnet system having a magnetic remanance 150% of previous sintered ferrite magnets can be used. An

N.I.B. magnet of this strength can be used with nearly conventional laminated armature designs.

However the extra magnetic flux in the system must be contained within a complete magnetic circuit in the motor. In the past it has been common practice on low cost motor designs to deep draw a steel can to act as the motor housing and provide the magnetic return path. To contain all the extra flux from such new more powerful magnets such housings would have to be drawn from thicker material or some double system such as the adding of a cylindrical collar to form an extra return path would be required.

The present invention provides a fractional horsepower PMDC motor having a stator comprising a permanent magnet and a housing carrying said magnet, said housing being formed by a stack of laminations and providing a return path for the magnet flux.

In this way a housing of increased wall thickness can be readily formed from suitable metal sheet, for example cold rolled steel, by stamping out the laminations and attaching them together to form the housing.

A further difficulty is that N.I.B. magnets are sensitive to changes in temperature to a far greater degree than ferrite magnets, for example at relatively low termperatures they lose flux and can become demagnetised.

Temperature rise in motors is a function of the watts loss in the motor and the thermal resistance of the motor. If the motor is producing more power, a greater temperature can be expected. To overcome this the motor's thermal resistance can be lowered so that whatever heat is generated in the motor is quickly dissipated to the ambient. The thermal resistance of a motor is a function of its surface emissivity and the area of its surface. It would be appropriate therefore to increase the surface area. This fact is well known and in larger motors using cast iron frames, fins are often formed in the casting. Such a practice is difficult with very small motors, particularly as there is often a limit on the overall size of the motor to meet the requirements of the appliance manufacturer.

Accordingly in a particularly preferred form of the invention the motor housing has a ribbed outer surface. The ribs may be formed from castellations

in the outer circumference of the housing laminations. The ribs increase the outer surface area of the housing.

Other preferred features and advantages of the invention will be apparent from the following description and the accompanying drawings.

The invention will be further described by way of example with reference to the accompanying drawings, in which:-

Figure 1 is a perspective view of a fractional horsepower PMDC motor embodying the invention, and

Figure 2 is a cross-sectional view along the line II-II of Figure 1.

Figure 1 shows an external view of a fractional horsepower PMDC motor 1 comprising a housing 2 having a ribbed tubular body part 3 formed by a stack of steel laminations 4, and a bottom end plate 5 and an end cap 6. The laminations 4 are stamped from low reluctance material, typically cold rolled steel, of thickness about 0.5mm to 1.0mm. The quality of steel used will depend on whether laminations for the

motor armature are to be stamped from the same material and the strength of the magnets to be used, which may affect in particular the armature design.

The end plate 5 may be of cast aluminium and carries a bearing (not shown) for supporting a shaft 7 of the motor and is apertured to provide ventilation of the motor interior.

The end cap 6 may also be of cast aluminium and carries a bearing 8 for supporting the shaft 7 and has apertures 9 for ventilation of the motor interior. The end cap 6 also carries brush gear (not shown). Terminals 10 protrude through the end cap for connection to a power supply for feeding current to the brush gear. The brush gear feeds current to a commutator (not shown) on the shaft 7 for supplying current to the armature windings (Figure 2). The end cap may be of plastics material, but a metal end cap is preferred for greater heat dissipation and resistance to temperature rise. The end cap may advantageously be of anodised aluminium.

In accordance with a preferred feature of the invention, the housing part 3 has ribs 11 on its outer surface. As seen better in Figure 2, the ribs

11 are formed by castellations on the outer periphery of each lamination 4 forming the housing part 3. An undulating or sinusoidal outer periphery may be used, but an angular periphery will provide for the maximum external perimeter, and hence external area of the housing part 3.

In the embodiment shown, each castellation 12 is generally trapezoidal in shape with an arcuate outer peripheral edge 13, the arc being centred on the motor shaft 7, and a pair of edges 14, 15. The castellations 12 are separated by arcuate valley bottoms 16. The edges 14, 15 are angled so that the perpendicular line 16, 17 from the inner end 18, 19 of an edge 14, 15 does not intersect the adjacent opposing edge 15, 14.

The inner edge 20 of each lamination 4 has two recesses 21 to form recesses in the stack for receiving an arcuate Niodymium - Iron - Boron magnet 22. The magnets 22 are held in the recesses in the formed housing part 3 by a leaf spring 23 positioned between a circumferential edge 24 and a boss 25a which separates the recesses 21. The other circumferential edges 26 abut the diametrically opposite boss 25b.

The width of the annular land between the inner edge 21 and the castellations 12 is designed to provide the appropriate return path for the magnets 22.

The increased mass of material provided in the housing, when compared to conventional deep drawn steel casings, increases the thermal time constant of the motor, thus delaying the motor's resistance to temperature rise, and provides a magnetic return path which will not be saturated when using high energy magnets. The provision of a ribbed surface lowers the overall thermal resistance of the motor, thus enabling fuller use to be made by the manufacturer of the high power output available with high energy magnets.

The laminations 4 may be held together by welding, rivetting, bolting or the like. In a preferred form, the laminations are stacked together on two bolts 27 which are each threaded at each end (one end 27a is shown in Figure 1). The end plate 5 and end cap 6 are also mounted on the bolts and the assembly held together by nuts 28.

Figure 2 also shows a cross-section through an armature 29 mounted on the shaft 7. Armature 29

comprises three mushroom-shaped poles 30 each carrying a winding 31. The armature is formed from laminations as is generally known in the art.

In some motor constructions the armature laminations and the housing laminations 4 may be stamped from the same material, thus minimising wastage. Where this is not appropriate, the housing laminations may be formed in two halves joined in the region of the bolts 26, shown schematically by the dotted lines 32. In this way, the stampings can be laid out to minimise the material wastage. Various configurations may be adopted at the join line 32, for example a dove-tailed configuration, to hold the lamination halves together.

Various modifications may be made to the described embodiment and it is desired to include all such modifications as fall within the scope of the accompanying claims.

CLAIMS

1. A fractional horsepower permanent magnet direct current motor having a stator comprising a permanent magnet and a housing carrying said magnet, the housing being formed by a stack of laminations and providing a return path for the magnet flux.

2. A motor as claimed in claim 1, wherein the magnet is held against an inner surface of the housing.

3. A motor as claimed in claim 2, wherein the inner surface is recessed, the magnet being located in the recess.

4. A motor as claimed in claim 1, 2 or 3, wherein the laminations are stamped from metal sheet.

5. A motor as claimed in claim 4, having a laminated armature, wherein the armature laminations are also stamped from the metal sheet.

6. A motor as claimed in claim 4, wherein the laminations are in two halves.

7. A motor as claimed in any one of claims 1 to 6, wherein the outer surface of the housing is ribbed.

8. A motor as claimed in claim 7 wherein the outer circumference of the laminations is castellated.

9. A motor as claimed in claim 8, wherein the castellations are generally trapezium shaped, the radially extending edges of adjacent trapezia being non-parallel.

10. A motor as claimed in claim 9, wherein a perpendicular from a radially inner end of a said edge does not intersect the facing edge of an adjacent castellation.

11. A fractional horsepower permanent magnet direct current motor substantially as hereinbefore described with reference to the accompanying drawings.

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